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**Appendix I:**

*Flow  
and  
Discharge:  
a simple  
estimation  
technique*

## APPENDIX I

# Flow and Discharge A Simple Estimation Technique

## I. “Simple Method” Volunteers Can Use for Estimating Flow

*[Adapted from USEPA (1997)]*

This section describes one method for estimating flow in a specific area or reach of a stream. *(Refer to Volume 2 of this manual series for background information about stream flow and discharge.)* It is adapted from techniques used by several volunteer monitoring programs and uses a float (an object such as an orange, ping-pong ball, pine cone, etc.) to measure stream velocity. Calculating flow involves solving an equation that examines the relationship among several variables including stream cross-sectional area, stream length, and water velocity.

One way to measure flow is to solve the following equation *(a modification of the equation described above)*: **Flow = ALC / T**

### WHERE:

- A =** Average cross-sectional area of the stream (stream width multiplied by average water depth).
- L =** Length of the stream reach measured (usually 20 ft.)
- C =** A coefficient or correction factor (0.8 for rocky-bottom streams or 0.9 for muddy-bottom streams). This allows you to correct for the fact that water at the surface travels faster than near the stream bottom due to resistance from gravel, cobble, etc. Multiplying the surface velocity by a correction coefficient decreases the value and gives a better measure of the stream’s overall velocity.
- T =** Time, in seconds, for the float to travel the length of L

## TASK 1: Prepare before leaving for the sampling site

Refer to *Volume I: Unit 4* of this manual series for details on basic field gear, apparel, and safety considerations. When measuring and calculating flow, include the following equipment:

- Ball of heavy-duty string, four stakes, and a hammer to drive the stakes into the ground. The string will be stretched across the width of the stream perpendicular to shore at two locations. The stakes are to anchor the string on each bank to form a transect line.
- Tape measure (at least 20 feet)
- Waterproof yardstick or other implement to measure water depth
- Twist ties (to mark off intervals on the string of the transect line)
- An orange and a fishing net (to scoop the orange out of the stream)
- Stopwatch (or watch with a second hand)
- Calculator (optional)

## TASK 2: Select a stretch of stream

The stream stretch chosen for the measurement of discharge should be straight (no bends), at least 6 inches deep, and should not contain an area of slow water such as a pool. Unobstructed riffles or runs are ideal. The length that you select will be equal to  $L$  in solving the flow equation. Twenty feet is the standard length most frequently used.

Measure your length and mark the upper and lower end by running a transect line across the stream perpendicular to the shore using the string and stakes (*Figure I-1*). The string should be taut and near the water surface.

The upstream transect is Transect #1 and the downstream one is Transect #2.

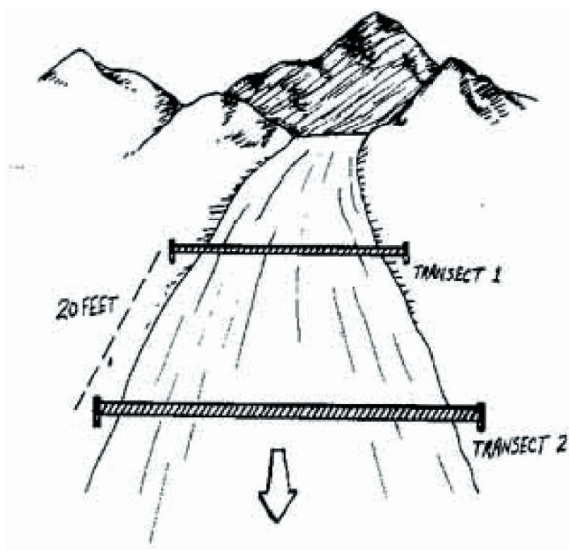


Figure I-1: Diagram of a 20-foot transect [from USEPA (1997)].

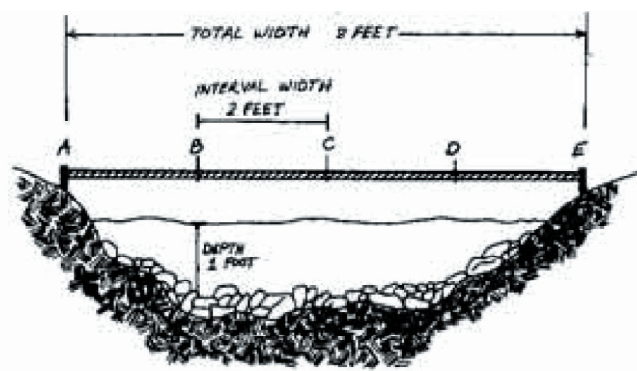


Figure I-2: A cross-section view of stream width and depth [from USEPA (1997)].



### TASK 3: Calculate the average cross-sectional area

Cross-sectional area (A in the formula) is the product of stream width multiplied by average water depth. To calculate the average cross-sectional area for the study stream reach, volunteers should determine the cross-sectional area for each transect, add the results together, and then divide by 2 to determine the average cross-sectional area for the stream reach.

#### To measure cross-sectional area:

1. Determine the average depth along the transect by marking off equal intervals along the string with the twist ties. The intervals can be one-fourth, one-half, and three-fourths of the distance across the stream. Measure the water's depth at each interval point (*Figure I-2*). To calculate average depth for each transect, divide the total of the three depth measurements by 4. (You divide by 4 instead of 3 because you need to account for the 0 depths that occur at the shores.) In the example shown in *Figure I-3*, the average depth of Transect #1 is 0.575 feet and the average depth of Transect #2 is 0.625 feet.
2. Determine the width of each transect by measuring the distance from shoreline to shoreline. Simply add together all the interval widths for each transect to determine its width. In the *Figure I-3* example, the width of Transect #1 is 8 feet and the width of Transect #2 is 10 feet.
3. Calculate the cross-sectional area of each transect by multiplying width times average depth. The example given in *Figure I-3* shows that the average cross-sectional area of Transect #1 is 4.60 square feet and the average cross-sectional area of Transect #2 is 6.25 square feet.
4. To determine the average cross-sectional area of the entire stream reach (A in the formula), add together the average cross-sectional area of each transect and then divide by 2. The average cross-sectional area for the stream reach in *Figure I-3* is 5.42 square feet.

Figure I-3:  
Simple Calculation

Determining Average Cross-Sectional Area (A)							
Transect #1 (upstream)				Transect #2 (downstream)			
Interval width (feet)		Depth (feet)		Interval width (feet)		Depth (feet)	
A to B	= 2.0	1.0	(at B)	A to B	= 2.5	1.1	(at B)
B to C	= 2.0	0.8	(at C)	B to C	= 2.5	1.0	(at C)
C to D	= 2.0	0.5	(at D)	C to D	= 2.5	0.4	(at D)
D to E	= 2.0	0.0	(shoreline)	D to E	= 2.5	0.0	(shoreline)
	----	----			----	----	
<b>Totals</b>	8.0	2.3			10.0	2.5	
Average depth = $2.3/4 = 0.575$ feet				Average depth = $2.5/4 = 0.625$ feet			
<b>Cross-sectional area of Transect #1</b>				<b>Cross-sectional area of Transect #2</b>			
= Total width X Average depth				= Total width X Average depth			
= 8.0 ft X 0.575				= 10.0 ft X 0.625			
= 4.60 ft <sup>2</sup>				= 6.25 ft <sup>2</sup>			
<b>Average area = (Cross-sectional area of Transect #1 + Cross-sectional area of Transect #2)/2</b>							
= $(4.60 \text{ ft}^2 + 6.25 \text{ ft}^2)/2$							
= 5.42 ft <sup>2</sup>							

## TASK 4: Measure travel time

Volunteers should time with a stopwatch how long it takes for an orange (or some other object) to float from the upstream to the downstream transect. An orange is a good object to use because it has enough buoyancy to float just below the water surface. It is at this position that maximum velocity typically occurs.

The volunteer who lets the orange go at the upstream transect should position it so it flows into the fastest current. The clock stops when the orange passes fully under the downstream transect line. Once under the transect line, the orange can be scooped out of the water with the fishing net. This "time of travel" measurement should be conducted at least three times and the results averaged--the more trials you do, the more accurate your results will be. The averaged results are equal to "T" in the formula. It is a good idea to float the orange at different distances from the bank to get various velocity estimates.

You should discard any float trials if the object gets hung up in the stream (by cobbles, roots, debris, etc.)

## TASK 5: Calculate flow

**Recall that flow can be calculated using the equation:  $\text{Flow} = \text{ALC} / T$**

- Continuing the example in *Figure I-3*:

Say the average time of travel for the orange between Transect #1 and #2 is 15 seconds and the stream had a rocky bottom.

The calculation of flow would be:

**WHERE:**

$$A = 5.42 \text{ ft}^2$$

$$L = 20 \text{ ft}$$

$$C = 0.8 \text{ (coefficient for a rocky-bottom stream)}$$

$$T = 15 \text{ seconds}$$

$$\text{Flow} = 15 \text{ seconds } (5.42 \text{ ft}^2) (20 \text{ ft}) (0.8) / 15 \text{ sec.}$$

$$\text{Flow} = 86.72 \text{ ft}^3 / 15 \text{ sec.}$$

$$\text{Flow} = 5.78 \text{ ft}^3/\text{sec.}$$

## TASK 6: Record flow on the data form

On the last page of this appendix is a form volunteers can use to calculate flow of a stream.

## DATA FORM FOR CALCULATING FLOW

$$\text{Solving the equation: Flow} = \frac{A L C}{T}$$

Where:

A = Average cross-sectional area of the stream. L = Length of the stream reach measured (usually 20 ft.).

C = A coefficient or correction factor (0.8 for rocky-bottom streams or 0.9 for muddy-bottom streams). T = Time, in seconds, for the float to travel the length of L.

### A: Average Cross-Sectional Area

#### Transect #1 (upstream)

Interval width (feet)	Depth (feet)
A to B = _____	_____ (at B)
B to C = _____	_____ (at C)
C to D = _____	_____ (at D)
D to E = _____	_____ (shoreline)
<b>Totals</b> <input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/> ÷ 4
= Avg. depth <input style="width: 40px;" type="text"/> ft	

#### Cross-sectional area of Transect #1

= Total width (ft) X Avg. depth (ft)

X  =  ft<sup>2</sup>

#### Transect #2 (downstream)

Interval width (feet)	Depth (feet)
A to B = _____	_____ (at B)
B to C = _____	_____ (at C)
C to D = _____	_____ (at D)
D to E = _____	_____ (shoreline)
<b>Totals</b> <input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/> ÷ 4
= Avg. depth <input style="width: 40px;" type="text"/> ft	

#### Cross-sectional area of Transect #2

= Total width (ft) X Avg. depth (ft)

X  =  ft<sup>2</sup>

(Cross-sectional area of Transect #1 + Cross-sectional area of Transect #2) ÷ 2 = Average Cross-sectional area

$$A = (\text{ } \text{ft}^2 + \text{ } \text{ft}^2) \div 2 = \text{ } \text{ft}^2$$

### L: Length of Stream Reach

ft

### C: Coefficient

### T: Travel Time

Travel Time  
of Float (sec.)

Trial #1    \_\_\_\_\_

Trial #2    \_\_\_\_\_

Trial #3    \_\_\_\_\_

Total     ÷ 3

= Avg. time  sec.

$$\text{Flow} = \frac{A L C}{T} = \frac{\text{ } \text{ft}^2 \times \text{ } \text{ft} \times \text{ } }{\text{ } \text{sec.}} = \text{ } \text{ft}^3/\text{sec.}$$